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ABSTRACT

This paper documents the results of a series of experiments conducted by the Institute for Defense Analyses on translating technical material from English to Vietnamese. The work was accomplished in support of the Office of the Deputy Director, Research and Engineering, Deputy Director for Southeast Asia Matters. The paper addresses the question of translation speed, number of errors, and quality assessment. Three different methods for measuring the quality of translations are examined: back-translation, knowledge testing, and performance. Translation costs and means of writing translatable English are also reviewed. It is concluded that: 400 words per hour is a reasonable speech expectation for technical material; quality of translation significantly affects performance, and quality may be sampled by any of the means tested; costs can be reduced by several methods but seventy dollars per thousand words is a reasonable estimate. (Author/FWB)

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EXPERIMENTS IN LANGUAGE TRANSLATION: TECHNICAL ENGLISH-TO-VIETNAMESE

H. Wallace Sinaiko
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INSTITUTE FOR DEFENSE ANALYSES
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400 Army-Navy Drive, Arlington, Virginia 22202

Contract DAHC15 67 C 0011
Task T-77

Fall down the rear seat back on the seat, and insert two stays at the both side of the floor on the top of the seat back into the small hole of the steel brackets on the back of the seat cushion.

Owner's manual, Datsun 1964 Station Wagon
(Manufacturer's translation from Japanese)

Performance Testing: Vietnamese Air Force Technicians
Adjust UH-1H Helicopter Main Power Plant

ACKNOWLEDGMENT

In order to carry out the experiments reported here, it was necessary to obtain the assistance of key people at the U.S. Army's Transportation School, Ft. Eustis, Virginia. In the face of an already demanding daily schedule involving a two-shift operation brought on by the need to train many Vietnamese as well as U.S. Army personnel, we were extended outstanding cooperation at Ft. Eustis. Several hundred Vietnamese airmen served as test subjects, and testing facilities, helicopters and expert observers were also made available. Therefore, it is with great appreciation and pleasure that we publicly acknowledge the contribution and help of the officers and men of the Transportation School, without which this work could not have been accomplished.

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I. SUMMARY AND CONCLUSIONS

PURPOSE

Translation of technical English is a critical aspect of the larger effort of transferring American military equipment to the armed forces of the Republic of Vietnam, because each item is accompanied by considerable documentation. Many issues are involved: Is it possible to translate with high quality from a highly technical language into one that is very limited in its technical terminology? What are the available resources for translation of English to Vietnamese? How fast can professional translators process technical material? What types of errors, if any, are made by translators and how frequently do they occur? How can finished translations be evaluated for fidelity (i.e., accuracy)? This study, undertaken at the request of ODDR&E, covered a series of investigations of several of these questions: the possibility of high quality translation, and assessment of speed, errors, and methods for quality measurement of translated technical English to Vietnamese.

Several experiments were conducted to provide: (1) information about different methodologies that could be used to assess the quality of translated technical English; and (2) data on factors that affect the quality of text translated from English to Vietnamese. Results of the experiments should be of value to both linguists and other behavioral scientists, and to Department of Defense agencies facing problems of turning over technical equipment to the RVNAF. The study demonstrates methods of measuring translation quality, and provides quantitative evidence about the significance of good technical translations. Further, there are guidelines for writing translatable English.

METHOD

Three techniques were used: (1) the analysis of back-translated Vietnamese, the technique in which one bilingual translates from English to Vietnamese and another bilingual translates back from Vietnamese to English; (2) the measurement of translation quality through knowledge testing of Vietnamese readers in their own language; and (3) the assessment of technical material—both translated Vietnamese and the original English text—through performance testing of technicians who must use the material to repair or adjust part of an aircraft.

English-to-Vietnamese translations, as well as back-translation from Vietnamese into English, were done by twelve highly skilled professional translators. All the material they translated was technical English, sampled from representative USAF tech orders, U.S. Army tech manuals, or Air Force job performance aids (e.g., PIMO).* Subjects who served as users of translated material were Vietnamese Air Force airmen being trained as helicopter technicians by the U.S. Army Transportation School, Ft. Eustis, Virginia. Finally, U.S. Army enlisted technicians, comparable in training and experience to the VNAF airmen, served as an experimental control group. Both American and Vietnamese subjects were probably typical of users of this type of material.

Analysis and review of translated Vietnamese were done by a linguist-consultant and, in some cases, by VNAF liaison officers. Back-translated material was analyzed by the experimenters.

RESULTS

Feasibility of Translation

Vietnamese is a language with virtually no technical terms. For this reason translators are forced to resort to one of several techniques in dealing with technical English:

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*Acronym for Presentation of Information for Maintenance and Operation.

- they may use French or Chinese or English, transliterated and presented in Vietnamese characters;
- they may coin new terms;
- they may use several available Vietnamese words to "explain around" the English term.

However, usable translations were produced by the 12 bilinguals hired for these experiments.

Translation Speed

Technical English can be translated into Vietnamese at about 400 words per hour (2400 to 3000 words per day), although unfamiliar material is handled at a somewhat lower rate.

Back translation into English, which may be necessary as a quality control technique, can be done about 10 percent faster, i.e., 450 words per hour.

There is no speed advantage for translators working with specially formatted proceduralized job performance aids such as PIMO, i.e., their output is the same as when translating conventional technical manuals.

Translators claim to be able to handle standard, nontechnical English to Vietnamese at rates of up to 1000 words per hour (a figure not verified in this study). The main reason for the much slower pace found here is an inherent characteristic of the Vietnamese language: technical terms are almost nonexistent and translators are forced to coin words or, more often, "explain around" many English words. For example, the frequently used aeronautical term "tachometer" may become "rotation measuring machine" in Vietnamese. Not only does the absence of a technical terminology affect the speed of translation, but it also results in widespread nonstandard usage, both by translators and readers.

Quality of Technical Translation

Given highly competent translators, careful review by equally skilled linguists, lexical aids such as technical glossaries, and a form of compensation that stresses

accuracy over speed, it is possible to produce accurate technical Vietnamese from standard U.S. military maintenance documents. This has been demonstrated by several approaches to assessing translation quality: back-translation, knowledge testing, and performance testing.

As a general finding, for every 100 words of technical English translated into Vietnamese, about five words or combinations of words are in error. While this may appear to be a low rate, in view of the operational importance of maintenance material the error rate should probably be close to zero.

Translator accuracy for job performance aids (e.g., PIMO material) is about the same as for conventional technical material.

Several types of changes/errors occur in translated Vietnamese: (1) words or phrases in the original corpus are omitted; (2) synonyms are substituted for directly equivalent terms; (3) functional descriptions are introduced when the technical English has no equivalent Vietnamese; (4) words or phrases are garbled; and (5) words are used which definitely change the meaning of the original (indicating, perhaps, a lack of understanding by the translator).

Irrespective of their bilingual abilities, good translators demand special glossaries and technical word lists, and their performance directly reflects the use of such aids.

There is little or no relationship between quality of translation and the speed of the translators in these experiments. This is true for English to Vietnamese, Vietnamese to English and a combined rate for the two directions.

Methods of Assessing Translation Quality

Each of the techniques employed in this study is sensitive to differences in translation quality and each has unique advantages.

Back-translation into English permits nonbilinguals to compare original texts with retranslations. The technique is relatively rapid. However, it is possible for

the back-translator to introduce new errors to the first translation, or to cancel errors, and there is no satisfactory way to prevent these things from happening.

Knowledge testing, in which subjects read a translation and answer questions about it, is highly sensitive to differences in translation quality. Average scores varied by more than a factor of two, i.e., 6.1 versus 2.6 on a ten-item test, for the best and worst translations. When the same man translated both PIMO and corresponding tech order material, knowledge test scores did not differ. Scores on knowledge tests correlated positively with independent ratings by experts on quality of translations and with an error analysis of back-translations. The technique is somewhat time-consuming to administer and it requires that test questions be written and translated; also subjects' answers must be scored in the target language.

Performance testing is a way of measuring the quality of technical translations by having readers perform a task using the translations. To the extent that such performance is good or bad, the translation is assumed to be good or bad as well. Our experiments showed that different quality levels of a translated technical manual were directly reflected in the work of crews of helicopter technicians. The best translation into Vietnamese resulted in performance on a very difficult, multi-step task at a level that was approximately equal to that of U.S. Army technicians who used the English manual. Error-free performance was observed for 73% of the tasks done by each group, U.S. Army and VNAF. Lesser-quality translations brought the corresponding figure as low as 11%. VNAF technicians using English, the language in which they had been trained, worked at a 41% error-free level. Performance testing is the most time-consuming of the quality assessment methods we used. It also requires the availability of equipment (UH-1H helicopters in our case) and the close cooperation of expert technical observers to evaluate subjects' performance.

Subjective opinion, as a method of evaluating quality of technical translation, is both inaccurate and misleading. Specifically, we have two reasons for making such an assertion: (1) some Vietnamese airmen, working with the best available translation, expressed dissatisfaction with having to read unfamiliar terms; in fact,

however, the performance of these technicians was much better than that of other VNAF technicians who used the English manual; and (2) technically competent bilingual reviewers called the poorest quality translation "...not bad..." when actual performance with that translation was the worst measured.

Cost of Technical Translation

Good Vietnamese translators are difficult to locate and their services are expensive. We paid each of the main group of translators $8.00 an hour. At this rate, plus a higher hourly fee for the consultant-reviewer, the best quality translation cost $140 for approximately 1000 words of English. To obtain lesser quality material we used the services of a commercial translation company and those of a single free-lance linguists at $39 and $30 per 1000 words, respectively. Neither of these translations had the benefit of a review. (The performance test results showed marked differences between the three quality levels.) We believe that the high cost of the best translation procedure could be brought down, perhaps by a factor of two, in a production operation. However, $70 per thousand words may be an excessive price to pay.

Translation of Proceduralized Job Aids and Conventional Technical Material

Proceduralized job performance aids (JPA) are improved ways of providing maintenance information to technicians. JPAs are written in a special format: they use standardized verb lists, sentences are short, and sentence structure is simplified (Sinaiko, et al., 1969). It was not the main purpose of this study to look into JPAs but, because at least one item of equipment (i.e., the UH-1H helicopter) is to have JPAs, we included some representative proceduralized material among the samples of technical English to be translated. This summary is based on translation speed trials, on back-translation analyses, and on knowledge test results.

There is no speed advantage for translators of JPAs versus conventional technical English.

Translator error rates are about the same for JPAs and technical English.

Types of errors are distributed almost identically between JPAs and conventional material.

Writing Translatable English

Based on an error analysis of the back-translations, we derived eight rules for writing English that will lead to more accurate translations into Vietnamese. The most important of these rules suggest avoidance of:

- long sentences, i.e., over 16 words
- complex noun phrases, e.g., "organizational maintenance activities"
- adverbs and prepositions indicating "where" or "when", e.g., "reasonably probable", "beyond".
- abbreviations, e.g., "Landing Gear Cont."

RECOMMENDATIONS

Following are what we believe to be the major, or priority, recommendations derived from this study:

1. Develop bilingual glossaries of technical terms and other translator aids.
2. Provide and require quality control in all technical translation, e.g., analysis of back-translation, knowledge testing and, if feasible, performance testing.
3. Compensate translators so as to put greater emphasis on accuracy than speed.
4. Do not rely on expert opinion to evaluate technical translations.
5. Prepare new technical documents using English that is likely to be translated accurately.

II. INTRODUCTION

> "...The most critical need...a year ago and today, is for material in the Vietnamese language... This is viewed as the most difficult job yet to be accomplished..." (Henderson et al., 1970)

Technical documents--maintenance manuals, technical orders, and instructional material--are as critical in the use of complex military equipment as the hardware itself. Training men how to use and service equipment is inevitably tied to the quality of the technical documents they are given. And in the case of material intended for foreign nationals--specifically, the Armed Forces of the Republic of Vietnam--there is an added class of problems: most of the intended users do not read English and documents must be translated. (An alternative solution, not treated in this study, is to train Vietnamese military personnel to read English, thus eliminating the need for translation.)

Language translation methods are as old as the printed word. But, surprisingly, there is almost no literature on the technology of translation, and on the accuracy that can be expected from it. One is forced to rely on the subjective views of translators or bilingual readers about the quality of a translated document.

Vietnamese is simple in structure. However, one characteristic of the language makes translations from technical English very difficult. That is, Vietnamese contains almost no technical terms. A related fact is that Vietnamese is not a precise language by Western standards. We have heard anecdotal evidence that Vietnamese frequently misunderstand each other when attempting to exchange exact information.

Because of its importance to the current program of turning over American military assets to the Vietnamese Armed Forces, the Deputy

Director for Southeast Asia Matters, ODDR&E, requested the Institute for Defense Analyses to initiate a study of technical translation. Since January 1970, IDA has conducted a series of exploratory experiments on translating technical material from English to Vietnamese. As part of the Department of Defense accelerated modernization program for the Vietnamese Armed Forces, the IDA effort was undertaken to obtain quantitative evidence about many translation problems. Is high quality translation from technical English to Vietnamese possible? How rapidly can language translators process technical English? How many errors do they make? What is the nature of translation error for this type of material? How does translation quality affect the work of Vietnamese technicians? Do some forms or styles of technical English permit better translations than others?

In addition to addressing these questions, we were equally concerned about more fundamental, and general, problems of assessing the quality of translations. Since relatively little work has been done on assessment, the IDA experiments were intended to provide information about different approaches to measuring the goodness of translations. What we have learned should also be of value to linguists and others who are concerned with quality control in language translation. In all cases, the methods of evaluating translations that we have used can be applied by people who themselves do not speak another language besides English.

It is important to indicate what this study does not treat. We did not deal with any aspects of automatic translation, i.e., full machine (computer) translation or machine-aided translation. (Pierce et al, 1966, do cover these issues.) Neither did we try to measure the relative merits of training Vietnamese in English or in their native language. Finally, although we used many Vietnamese airmen as test subjects in the experiments, our results should in no way be construed as an evaluation of the abilities of those men.

The work reported here is an extension of an earlier study, also for ODDR&E, on training Vietnamese to operate and maintain complex military equipment (Sinaiko et al, 1969).

III. METHODOLOGY

This chapter describes the approach used in the study of translations between technical English and Vietnamese. The linguist-consultant and 12 translators are described, as are the technical materials on which the translators worked. Also covered are the three methods that were used to study the speed and/or quality of translation: back-translation, knowledge testing, and performance testing.

BILINGUAL CONSULTANT

A highly skilled consultant was hired who assisted in several phases of this investigation. He possessed the following qualifications: Vietnamese native, university teacher in Vietnam, 20 years in the U.S., Ph.D. in educational psychology with additional training in linguistics, experience with translating technical materials, has taught Vietnamese how to translate. This consultant recruited 12 translators considered by him to be the best available and he evaluated much of their work.

TRANSLATORS

The 12 bilinguals worked for a minimum of eight hours, translating and back-translating, as well as telling us what problems they encountered and what aids might make their translations faster and better. Biographical information on the 12 bilinguals was gathered from them so that their qualifications can be described.

At the time of these experiments, seven of the 12 bilinguals worked for the Voice of America as professional translators. One

worked for IBM, one for the State Department, one was a Ph.D. and another a Ph.D. candidate, and one was a language teacher. All were born in Vietnam, Vietnamese being their first language, and had spent an average of 28 years there. All had taken formal courses in the Vietnamese language through the secondary school level in Vietnam. On the average, the 12 bilinguals had spent 10 years in the United States. Ten of the bilinguals had attended accredited American universities for an average of 4.9 years with the language of instruction, of course, being English.

All 12 had worked either part-time or full time as translators for an average of 11 years. Surprising to us, all 12 had translated some technical materials in the past. None, however, had ever translated technical materials as a full time job. The materials that they had translated included a book for a basic electronics course and manuals for (1) weapons, (2) diesel and automobile engines, (3) a mine sweeper, and (4) farming equipment. In addition, some had translated glossaries of military flying terms and psychological terms.

MATERIALS TO BE TRANSLATED

Since one purpose of this research was to investigate whether or not adequate translation between technical English and Vietnamese is possible, we chose three types of technical materials with which the bilinguals would work. All three were the types of materials that must be translated from English to Vietnamese as part of Vietnamization. The three types, and a description and sample of each, are:

1. The technical manual for the UH-1H helicopter (TM 55-1520-210-20). This document was chosen since the translation of it is critical to a priority item. The document is in the conventional tech manual form, with each system of the aircraft covered by a chapter. Tech manuals form the basis of training programs and are used as texts. They are also used as working guides by technicians. Criticisms of tech manuals (summarized by Sinaiko et al., 1969) include:

(a) manuals are organized more for building hardware than maintaining it, and

(b) many manuals are difficult to read and use, and do not emphasize troubleshooting for the repairman.

In this research, Chapter 7 on the "Power Train System" of the UH-1H helicopter was translated by the 12 bilinguals. A sample from the Chapter follows. Another sample is contained in Appendix A.

7-1. PURPOSE.

7-2. This chapter provides all the instructions and information necessary for maintenance authorized to be performed by organizational maintenance activities on the power train system. The power train is a system of shafts and gear boxes through which the engine drives main rotor, tail rotor, and accessories such as DC generator and hydraulic pump. The system consists of a main drive shaft, a main transmission which includes input and output drives and the main rotor mast, and a series of drive shafts with two gear boxes through which the tail rotor is driven. (See figure 7-1.)

2. The job performance aids (JPA) for the C-141A aircraft. More specifically we used PIMO (Presentation of Information for Maintenance and Operation), a relatively new method for presenting technical maintenance information. Like other JPAs, PIMO is formatted differently in the hope of being more understandable. This new format was designed so that technicians could read and use the PIMO materials more easily than the conventional USAF tech order (T.O.). The new format includes (Goff et al., 1969; Sinaiko et al., 1969):

   (a) organization of maintenance tasks based on experimental analysis of the mechanic's job and of the aircraft

   (b) a fixed syntax, including a common sentence structure and recommended maximum sentence length

   (c) a standardized verb list

(d) limited amounts of information in each maintenance step, corresponding to empirical studies of the mechanics' memory span.

PIMO has fewer different verbs, uses shorter sentences (than the T.O.), and there are many sketches corresponding to instructions. There is great interest in the Air Force for the PIMO type of presentation, and we wanted to see if it offers any advantages for translation over conventionally prepared technical orders. In this research, a section of Volume 18 entitled, "Operational Checkout of Normal, Emergency, and Parking Brake Systems" was translated by the 12 bilinguals. Examples from both the page giving the description of the material and personnel required, and a set of instructions for a single task, are presented here.

The excerpts from Volume 18 illustrate the PIMO format:

OPERATIONAL CHECKOUT OF NORMAL, EMERGENCY AND PARKING BRAKE SYSTEMS

INPUT CONDITIONS

Applicable Serial Nos.

All

Special Tools and Test Equipment

Brake Pressure Tester, 3S50018
Push-pull scale

Supplies

Four maintenance in progress tags, No. 1492.
Eight circuit breaker labels to indicate maintenance in progress.
Three labels to indicate maintenance in progress.

Personnel Required: Two

Man A performs activity in flight station.
Man B starts at left main landing gear.
Specialist will be required to operate hydraulic cart when requested.

FIGURE 1. PIMO Material for C-141-A, Page 5-1, Volume 18

The following figure, also from Volume 18, shows a set of instructions for a maintenance task. The sketches on the right correspond to the instructions on the left.

OPERATIONAL CHECKOUT OF NORMAL AND EMERGENCY BRAKE SYSTEMS — MAN A

NOTE

Do not continue until man B requests that hydraulic system be pressurized.

1. **Push pilot's and copilot's rudder pedals until rig pin can be installed. Install rig pin.**

2. **Request that specialist apply pressure to No. 2 hydraulic system.**

3. **Turn three hydraulic system No. 2 switches to ON.**

   Check that pressure indicator reads 3000 (± 250) psi.

4. **Set brake selector switch to NORM.**

   Check that normal brake pressure indicator reads 3000 (± 250) psi.

   Report to man B.

NOTE

If one tester is being used by man B for check of normal and emergency brakes, go to next frame. If two are used, go to Frame 24.

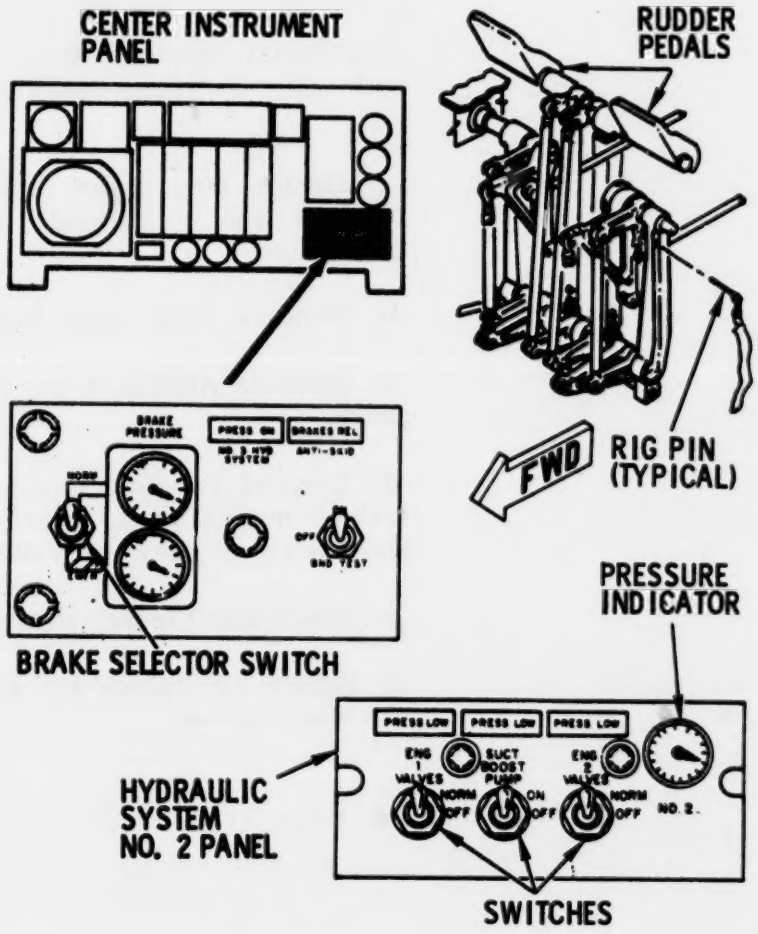

FIGURE 2. PIMO Material, Page 5-6, Volume 18

3. The USAF's Technical Order for the C-141A (T.O. 1C-141A-2-12). This document was chosen in order to compare translations of the same material written in the PIMO form, described above, and in the T.O. form, also described above. The qualities of the T.O. for the C-141A are similar to those of the UH-1H T.M., already described. In this research, the 12 bilinguals translated all or part of Chapter 8 of the C-141A T.O. entitled, "Main Landing Gear Brake and Anti-Skid System." This chapter covered the same material on the brake system, but in

a different format, as the PIMO aides. A sample from the C-141A T.O. follows:

8-22A. PREPARATION FOR NORMAL AND EMERGENCY BRAKE SYSTEM OPERATIONAL CHECKOUT. (See figure 8-4A.) The following steps are required to prepare for normal and emergency brake system operational checkout. Refer to paragraph 8-23 for normal and emergency brake system operational checkout.

a. Obtain two brake pressure and bleed testers 3S50018 and appropriate containers for collecting bleed fluid.

b. Remove dust caps from ends of tester hose.

c. Remove AN6204-1 bleed valves from brake bleed ports.

d. Connect the eight long tester hoses (4 hoses each tester) numbered 1, 2, 3 and 4 to brake assembly bleed ports (4 hoses each side).

e. Place short tester hose into container.

f. Insure all valves are closed on brake pressure and bleed tester.

FIGURE 3. Page from USAF Tech Order, T.O. 1C-141A-2-12

TRANSLATION TASKS

The 12 translators worked on different tasks, and their total time for each translation task was recorded. Some of the tasks involved translation between English and Vietnamese, and some involved back-translation between Vietnamese and English. The tasks on which translators worked will be described here since these tasks provided the raw materials used in subsequent tests of translation quality.

Each of the 12 Vietnamese-English bilinguals translated or back-translated for eight hours. During this time, there were eight different translation or back-translation tasks to be performed. Of the eight tasks, all 12 bilinguals translated in at least three tasks, and all 12 back-translated in at least one task. For the other four

tasks, six of the bilinguals translated two more times and the other six bilinguals back-translated two more times. Table 1 explains the eight tasks and the number of bilinguals performing each task.

TABLE 1. EIGHT TRANSLATION TASKS AND NUMBER OF BILINGUALS PERFORMING EACH TASK

Task 1

6 bilinguals translate 200 words from UH-1H T.O.

6 bilinguals translate 200 different words from UH-1H T.O.

Task 2

Each of the 12 bilinguals back-translates material he did not translate for Task 1

Task 3

12 bilinguals form 6 teams of 2 and team-translate additional UH-1H material for 90 minutes

Task 4

6 bilinguals translate material from C-141A T.O. for 90 minutes

Task 5

6 bilinguals back-translate materials from Task 4

Task 6

6 bilinguals translate material from PIMO aids for the C-141A for 90 minutes

Task 7

6 bilinguals back-translate materials from Task 6

Task 8

5 bilinguals* who back-translated in Tasks 5 and 7 translate materials from either T.O. or PIMO aids for C-141A

NOTE: UH-1H T.O. refers to TM 55-1520-210-20, chapter 7
C-141A T.O. refers to T.O. 1C-141A-2-12, sections 8-22A and 8-23
PIMO aids for C-141A refers to Volume 18, section 5

*Six bilinguals were given Task 8, but only 5 were able to complete it.

All 12 bilinguals worked in quiet rooms and had access to an English dictionary (Webster's Seventh Collegiate Edition). Tasks 1, 2, and 3 (in that order) were performed during a four hour session on one day, and Tasks 4 through 8 were done on a second day. On the second day, three translators performed Task 4 (C-141A T.O.) and then did Task 6 (C-141A PIMO materials), while the order was reversed for the other three translators. This was done so that a PIMO and T.O. comparison would not be confounded with practice, that is, all six working on one form of English and then the other. The order was also balanced for the six back-translators doing Tasks 5 and 7. Task 8 always followed Tasks 5 and 7 for these six bilinguals. The instructions to the subjects were as follows:

INSTRUCTIONS TO TRANSLATORS

We would like you to translate the document that you have in your hands into Vietnamese. We are more interested in a good quality translation than in speed, so please take your time so that you can do the best job possible. Sometimes you may find an English word or phrase that does not have an equivalent word in Vietnamese. In such a case, you can do one of two things.

1. "Coin" a Vietnamese word or phrase and circle it with a red pencil. (Make sure that the term "coin" is understood.)

   Dung dich này có (dắc tính làm rĩ) kim khí.
   Circle in red

2. Or, if you feel that you don't want to coin a word, just write the English word or phrase in the proper place, and circle it in blue ink, as in the following example:

   Dung dich này có (highly corrosive) kim khí.
   Circle in blue

Please keep track of the words that you coin. On the yellow sheet that you see, write the English word or phrase in the first column, and then write your coined translation in the other column. The following example will help.

English Word or Phrase	Your Coined Translation
piston	pít tông
handle throttle	cần ngạt gió

Please try to coin a word wherever possible, but remember that we understand that you will not always be able to coin a word.

Feel free to take short breaks whenever you are tired, and to ask questions of one of us, who will be near you, either in this room, or by a quick phone call to 664 or 667. (Show phone in room.)

Remember that we are interested in as good a translation as you can do.

Translation rate for each of the eight tasks was measured by stop-watch.

MEASURING TRANSLATION QUALITY

Back-Translation

One method for evaluating translation quality is back-translation, specifically, comparing the original English and the back-translated English. In the back-translation technique, the investigator asks one bilingual to translate from the original to the target language, and then he asks another bilingual to translate back from the target to the original. The advantage of the technique is that, as opposed to other methods that have been suggested (e.g., Miller and Beebe-Center, 1956; Carroll, 1966), the translation evaluator does not have to understand or speak the target language. A weakness is the fact that any mistakes in the back-translation may be due either to the translator or to the back-translator. Thus, even though we evaluate back-translation to obtain insights about translation, a perfect translation can be misinterpreted by an incompetent back-translator, or a good back-translator can "correct" a poor translation. This is why back-translation should always be complemented by other techniques, such as knowledge testing, to be described below.

Knowledge Testing

"Knowledge Testing" refers to a method of evaluating translation quality in which subjects read a translated passage and then answer a set of questions about the content of the passage. If subjects can answer all the questions, the translation is assumed to be a good one. While the knowledge testing technique resembles the standard reading comprehension method, it differs in one important respect. Measures of reading comprehension contain items of graded difficulty, and are sensitive to individual differences. Knowledge testing is designed to elicit perfect scores if the translation is good, and should be independent of individual differences. Suggested by Miller and Beebe-Center (1956) and by Macnamara (1967), the technique was first used by Brislin (1969). The knowledge test method was used in our studies of translation to Vietnamese since it provides another approach to the assessment of translation quality in addition to comparisons of original and back-translation, described earlier. This approach asks, "How well can people read and understand Vietnamese that has been translated from English?" The knowledge testing technique requires the researcher to write a series of questions in English about a passage and have them translated. He must also secure subjects who will read the passage and answer the set of questions. Tests must be scored by readers of Vietnamese, too.

Performance Testing

This technique has subjects perform a task requiring them to use either English or translated instructions. To the extent that subjects can complete the task, the translation is regarded as equivalent to the original English text. As in the evaluation techniques previously described, the experimenter does not have to know the target language since he only has to assess the product of the translated performance instructions. Brislin (1969) had subjects complete a picture using colored pieces of paper, scissors and paste, following eight separate steps. The task was to produce a picture after reading instructions in English or one of three Austronesian languages. Since

virtually all subjects were able to do the task without error, the translations were termed "equivalent". As far as we know, this was the first use of performance tests to evaluate translated English.

Performance tests can be scored objectively. In the present experiment a very demanding 12-step adjustment task on a portion of a helicopter engine made up the performance test. Three-man crews worked together and the nature of the task required them to follow written instructions with care. Each of the 12 steps was assessed by a technically qualified observer as "error free," "minor error" or "major error." (Appendix A contains the complete task as extracted from the larger helicopter technical manual.)

Performance testing is the most stringent translation evaluation technique since it demonstrates the quality of a translation by observable behavior of subjects. However, the technique is the most expensive and time consuming of the three we have used because the experimenter has to: (a) define a suitable task, (b) have it translated, (c) provide materials, e.g., a helicopter, (d) secure suitably trained subjects, e.g., Vietnamese and U.S. Army technicians, (e) have the subjects perform the task, and (f) obtain the services of observers who are technically competent to grade the task.

Recapitulation: Three Methods Compared

The experiments reported in this study are based on three approaches to assess the quality of translation: (1) back-translation, (2) knowledge testing, and (3) performance testing. None of the three methods described requires that the experimenter have proficiency in the target language, although each approach requires the services of linguist-translators. Relatively greater demands are placed on translator services in the first two methods than the last; particularly in the use of knowledge testing, translators must be used for the basic English text, the questions to be answered, and as test scorers. Back-translation puts an analytic burden on the experimenter that is not present for the other techniques. However, there are no test items to be developed for back-translation, while such items are at the heart

of knowledge tests. Performance testing may require that a task be designed although, as in the present experiments, an available task was used. In addition to translators, test subjects are required for knowledge and performance testing; this is not so with back-translation. Only in the case of performance tests are technical experts needed to evaluate what subjects do. Similarly, special equipment or material is needed for performance tests but not for the other two approaches. The relative costs of the three methods are probably in this order (low to high): back-translation, knowledge tests, performance tests. Finally, confidence in results or validity of the methods is likely in the same order. Table 2 summarizes the characteristics of the methods.

TABLE 2. COMPARISON OF THREE TRANSLATION EVALUATION METHODS

Characteristic	Back-Translation	Knowledge Testing	Performance Testing
Experimenter Proficiency in Target Language	No	No	No
Translators Needed:			
Original Text	Yes	Yes	Yes
Test Items	No	Yes	No
Scoring Tests	No	Yes	No
Back-translating	Yes	No	No
Test Construction	No	Yes	Yes (but may use available task)
Technical Experts as Observers	No	No	Yes
Special Equipment Needed	No	No	Yes
Relative Cost	Lowest	Middle	Highest
Confidence in Results	Lowest	Middle	Highest
Test Subjects	No	Yes--Any reader of the language	Yes--must be trained in the task

IV. RESULTS

This chapter presents the findings of our investigations. The first set of data summarizes our study of the speed of translation. This section is followed by the section explaining how to assess translation quality by means of three methods: (1) back-translation, (2) knowledge testing, and (3) performance testing. Also included is a short section on how English can be written in such a way as to be more easily translatable than the materials used here.

TRANSLATION SPEED

The results for translation speed are best presented in graphic form with the x-axis representing the order in which tasks were performed and the y-axis representing the number of words translated per hour. Figure 4 shows speed on the five translation tasks that bilinguals performed. Figure 5 shows speed on the three back-translation tasks that bilinguals performed. The tasks are arranged in the order they were administered.

There is one assumption involved in Figure 4. The fifth entry on the x-axis represents the efforts of five translators (see Table 1, Task 8) who translated at Tasks 1 and 3 on Figure 4, but back-translated two times (Tasks 5 and 7, Figure 5) instead of translating two times as did those six bilinguals representing Tasks 4 and 6 in Figure 4. We assume, however, that the time spent back-translating provided similar practice to that obtained by translating, and thus we include them as the fifth task in Figure 4.

The time designations (or tasks) on the x-axis have either 5, 6, or 12 speed scores, corresponding to the numbers in Table 1.

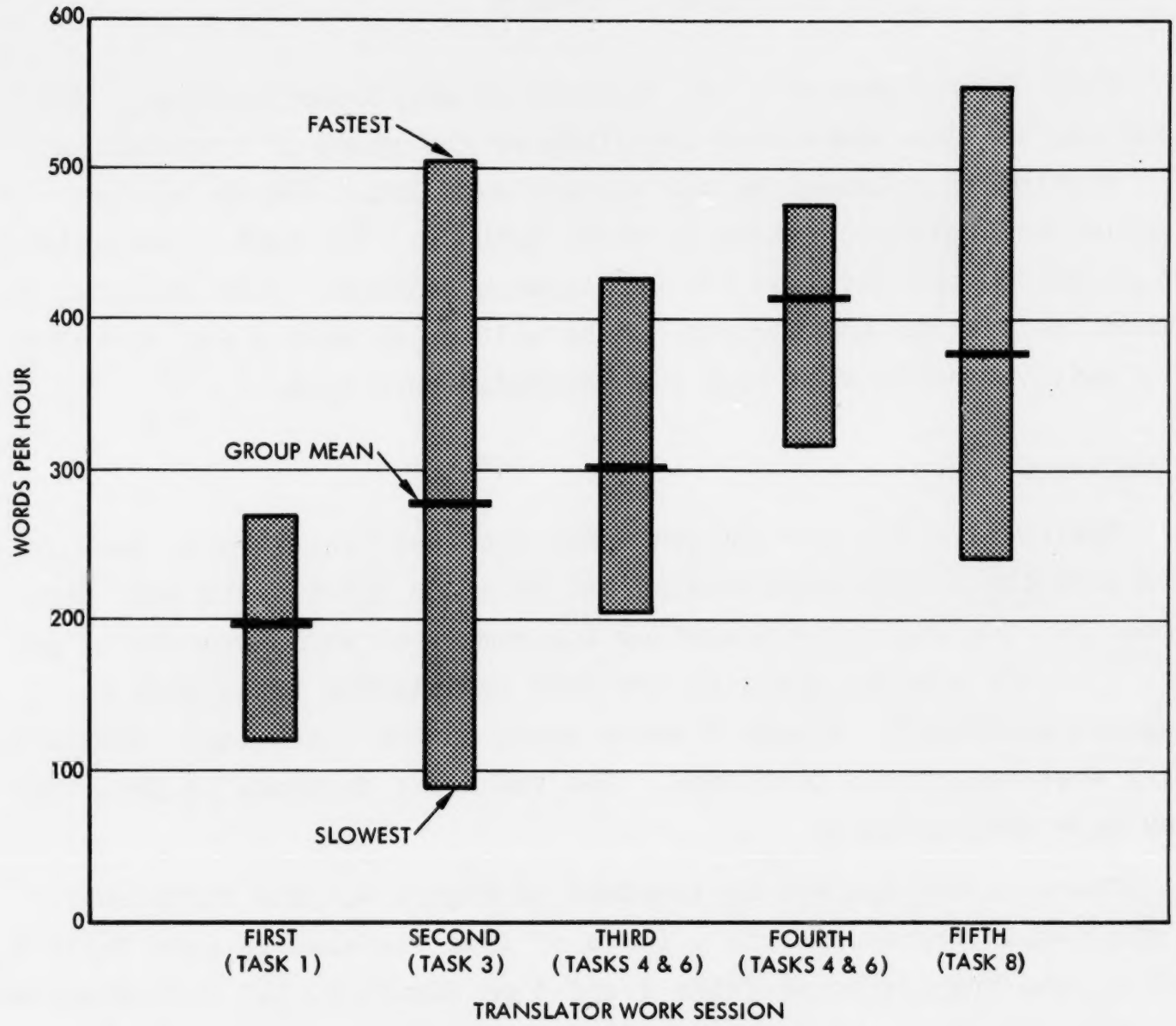

FIGURE 4. Speed of Translation

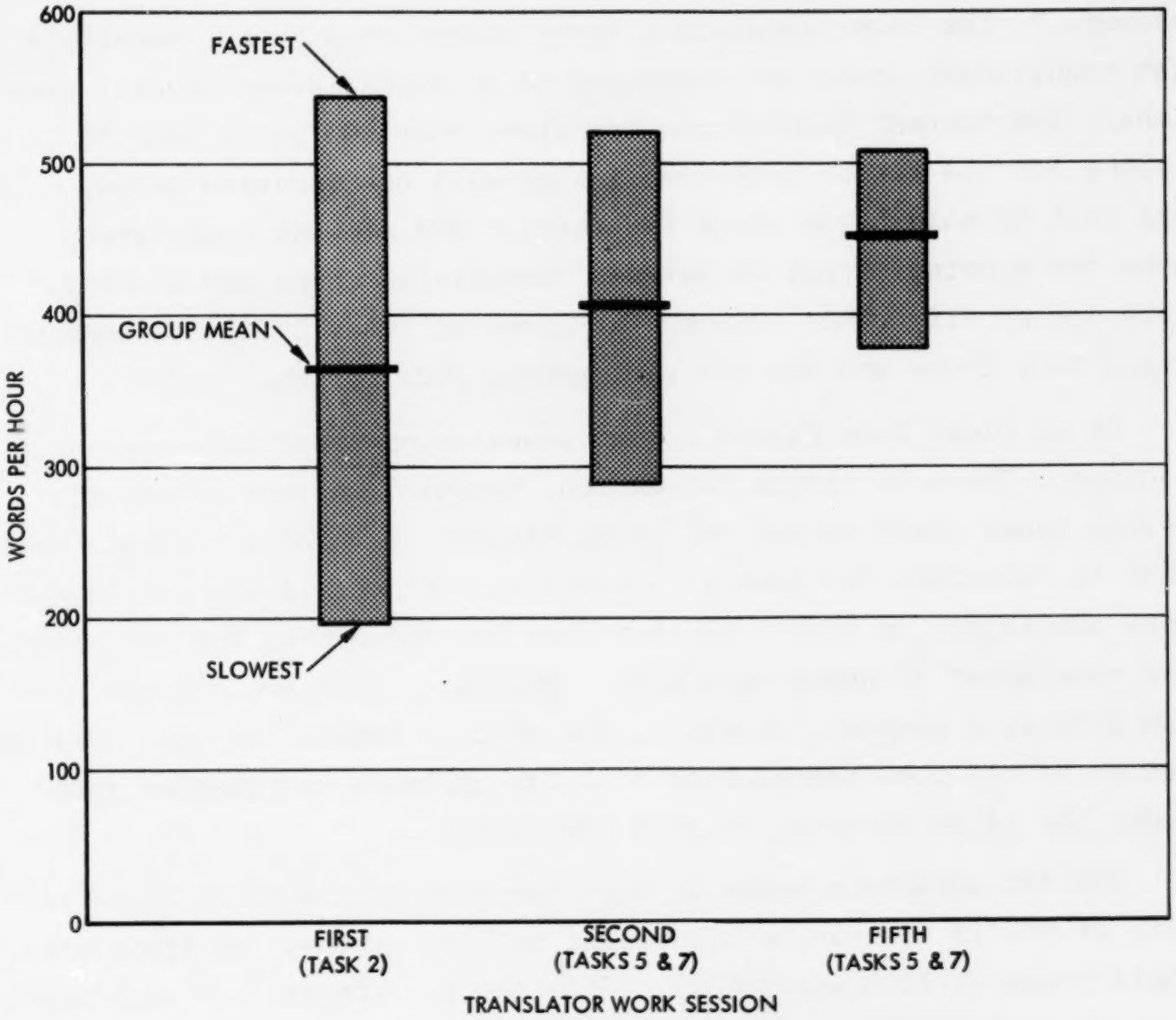

FIGURE 5. Back-Translation Speed Scores

It will be noted that the mean translation speed increases as the number of times a bilingual translates or back-translates increases. Statistical tests (t-tests) reveal that the differences between the first and last translation tasks are significant at less than the .05 level for both translation and back-translation. The final mean translation speed seems to be about 400 words/hour after practice during early sessions, and the final mean back-translation speed seems to be about 450 words/hour after practice during early

sessions.* The back-translation speed starts at a higher magnitude than translation speed and continues to be higher after several sessions. The fastest workers can translate over 500 words/hour.** Reasons for the faster back-translation will be discussed below. More will be said below about the fastest and slowest translators under the heading "Relation Between Translation Speed and Quality." There was no difference between the speed of translating the conventional tech order and the job performance aids for the C-141A.

It is clear from Figure 1 that translation speed increases with practice. There is little indication, however, whether or not the average speed could exceed 400 words/minute. Several bilinguals were asked to translate for several additional sessions (above and beyond those summarized in Figure 1), but they did not exceed the 400 words/hour rate after 20 hours more work. However, these men did not have such aids as a complete glossary, and thus it remains an open question whether or not good translation aids can increase translation speed beyond the rates observed in this experiment.

The 400 word/hour score is slow compared to the often heard reports of the 12 Vietnamese bilinguals telling us they can translate simple prose at 1000 words/hour. This latter rate was not verified in these experiments. Of course, the difference between those scores lies in the nature of the materials. The technical English translated here (examples given in the methodology chapter and Appendices)

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* We know of only one comparable study reporting translator rates for technical material (Pierce et al., 1966). The material was scientific Russian-to-English and translators worked at rates of 240 words/hour or about 2000 words/day. Brislin (1969) did not record exact times, but a rough figure would be 300 words/hour for translations between English and Austronesian languages (languages of Pacific Islands). The material consisted of prose passages about art, child-rearing and ethnic relations.

** This figure is identical with current experience reported from Vietnam: "...The best technical translators can manage 500 words per hour--if no special problems arise--for about six hours per day..." (Personal communication, January 23, 1970, from Dr. Jack von Dornum, International Training Consultants, Inc., Saigon.)

is much more difficult than the light prose, of say, a Reader's Digest article. Much of the time involved in a translation session is not in translating itself, but rather in understanding such complex phrases as: "Nose and hydraulic system reservoirs must be properly serviced." A further time consuming effort is the thinking of or explaining of technical words like "hydraulic system reservoirs." Another example of an even more difficult sentence is: "Reinstall bolt connecting actuator to governor control lever, adjusting actuator shaft rod-end to obtain 0.010 inch clearance between governor stop arm and upper stop screw, measured with a feeler gage."

This leads us to an explanation of the faster initial and final speed of the back-translators (Figure 5) as opposed to the translators (Figure 4). The translators had to spend time understanding the technical terms and explaining them in simple Vietnamese. For instance, the translators looked at the word "tachometer" and then had to spend time understanding that this meant "rotation measuring device." They then translated the latter three words to Vietnamese. The back-translators had the advantage, then, of not having to spend time explaining technical terms since they read the simpler phrasings provided by the translators. For instance, they simply read the equivalent of "rotation measuring device" in Vietnamese, and wrote down the three word phrase in English. The back-translators didn't have to use the word "tachometer" at all.

This transformation of technical English words to simpler English, and then to Vietnamese, is called "the explain-around technique" by the present investigators. Wickert (1957) noted that he experienced the same technique when he asked Vietnamese to translate abstract concepts. Another example of "explaining around" that we encountered was the translation of the technical term, "by-pass valve." The simpler English actually translated was, "a valve used to pass fluid in the way not normally used."

QUALITY MEASURED BY BACK-TRANSLATION

Some Vietnamese-English bilinguals translated the technical English materials to Vietnamese, and others back-translated to English. The back-translated English was analyzed by one of the experimenters. This section summarizes his analysis about the quality of the translations.

The 12 bilinguals translated and back-translated three types of materials, the T.O. for the UH-1H and C-141A, and the PIMO aids for the C-141A. The efforts of the 12 bilinguals were explained previously in Table 1. The efforts of these 12 bilinguals produced 9,558 words of back-translated English, distributed as follows:

2400 words of the UH-1H T.O.
3486 words of the C-141A PIMO aids
3672 words of the C-141A T.O.

Designation of Errors

Every word of the back-translated English was compared to the original English, as in the following example:

Original English	Back-Translated English
Man A performs activity (a test) in flight station	Mechanic A carries out the testing while in flight

In this example, the only combination of words that caused an error in the meaning of the back-translation as compared to the original English is the substitution of "while in flight" for "flight station." All other words are judged to be equivalent.

The criterion for an error was simply this: any place in the back-translation that is not judged to convey the same meaning as the original English is called a meaning error. Meaning errors could be of six types:

1. an addition: a word or phrase in the back-translation does not have an equivalent in the original

2. minor omission: one or two words from the original are omitted from the back-translation, and there is nothing in the back-translation to replace them

3. major omission: same as 2, but involving three or more words

4. garbling: three or more words from the original are garbled in the back-translation and are not understandable

5. minor substitution: one or two words from the original do not have an equivalent in the back-translation, but there is a phrase to replace the original words. Example: the original "flight station" is back-translated as "in flight."

6. major substitution: same as 5, but involving 3 or more words.

Finally, the back-translation could be equivalent to the original and marked, "O.K."

Our error analysis does not say anything about the operational seriousness of an error. We do not know, for example, whether a substitution error or addition of words would result in poor maintenance to the extent that a helicopter would operate in an unsafe condition.*

Specific Method of Comparison

Each of the three types of technical materials (described in Table 1) was arbitrarily divided into phrases averaging 8-9 words. All phrases were either a complete sentence or contained a complete thought. For instance, the slash separates the phrases in the following long sentence, and the second sentence forms a phrase by itself:

---

*There is evidence that errors in tech manuals can cause serious accidents. For example, the loss of a U.S. Navy aircraft, in 1969, was traced to an improper installation of a safety wire that, in turn, was due to "deficiencies in the technical documentation..." In addition to the aircraft, eleven lives were lost. (Smith, G.H., 1970.)

Open each valve, observing the sight gage/until
sight gage is free of air bubbles, then close.
Repeat for all upper valves on both testers.

Dividing into phrases made it easy to look at a meaningful unit in the original and to find the equivalence or non-equivalence of that unit in the back-translation. A given phrase could have more than one error. Each phrase, then, was tallied into one or more of the six error categories, or the "O.K." category. In addition, the exact wording that caused each error was noted.

Since the back-translations of all three types of technical materials were examined, comparisons among their back-translation scores can be made. This is possible since either all 12 bilinguals translated and back-translated the material (as in the UH-1H T.O.), or the 12 bilinguals were randomly assigned to translate or back-translate the material (as in the C-141A PIMO aids and the C-141A T.O.). Thus, the quality of the people involved in work on the three types of material should be equivalent, and any differences should be due to the nature of each type of material.

Computation of Quality Scores

The three types of quality scores used in this experiment will be discussed.

1. The first score is computed by taking the total number of meaning errors found in each back-translation and dividing it by the total number of original words translated.

2. The second score is computed by taking the total number of <u>different</u> errors found in the back-translation and dividing it by the total number or original words translated. That is, since a given back-translation can contain the same error made more than once (e.g., the term "circuit breaker" omitted three times), the number of different errors will be less than the total. For instance, in the above example, the <u>total</u> score will contain the three omissions of "circuit breaker," but the different error score will contain only one error for this series of omissions.

For instance, a score of 4.5/100 words says that for every 100 words of original text there are 4.5 words or combination of words in error in the back-translation. However, this score does not tell what kinds of errors were made. For this reason, a further analysis was made based on what types of errors were made within each phrase of the technical materials. This analysis constitutes the third type of quality score.

3. As explained above, the technical materials were divided into phrases which were either a complete sentence or a complete thought. Each phrase was analyzed to determine what type of error was made within it or whether it was "O.K." If more than one error was made within each phrase, the more serious error (in the rater's judgment) was noted for that phrase. Thus, if a document had 70 phrases (about 560-630 words since a phrase equals about eight to nine words), a certain percentage of the 70 phrases would contain an error, specifically marked as to which of the six types of error, and a certain percentage would be "O.K." Cases in which there was more than one error per phrase were rare.

Findings

Listed below are several examples of what can happen to a passage of moderately technical prose, taken from Chapter 7 of the UH-1H manual, "Power Train System."

First, of course, a translation can be accurate:

Original: "leaks occurring beyond relief valve could cause some indication of low oil pressure."

Back-translation: "If oil is leaking at the outside of the pressure relief valve, it can activate the warning of oil low pressure."

Second, an omission can occur:

Original: "This chapter provides all the instructions and information necessary for maintenance authorized to be performed by organizational maintenance activities on the Power Train System."

Back-translation: "This chapter lists all the instructions and information necessary for the maintenance of the Power Train System. The maintenance has to be assigned to an authorized unit." (Note that "organization" is omitted.)

Third, the translator makes a substitution:

Original: "...two gear boxes through which the tail rotor is driven..."

Back-translation: "These gear boxes activate the tail fan blade."

Fourth, translators garble terms that result in definite changes of meaning; and leave an ambiguous, sometimes nonsensical, phrase in the back translation.

Original: "Troubleshooting precautions."

Back-translation: "Preventions while repairing."

The average number of words or combination of words in error per 100 words (quality score 1) and the average number of different words or combination of words in error per 100 words (quality score 2) are presented in Table 3 for each of the three types of technical material. The numbers of translators and back-translators who were involved in working on each type of material are also given, as are the total number of words on which the error scores are based. The reliability of the back-translation examination technique is adequate. An independent rater examined the 12 back-translations of the UH-1H material. Agreement between the two raters resulted in high reliability coefficients: $r = .88$ for the number of errors per passage; $r = .94$ for the number of different errors.

The analysis of errors by phrase (quality score 3) is presented in Table 4. The numbers of translators, back-translators, and words are the same as in Table 3. The "total phrase" figure in Table 4 represents the total number of phrases that all bilinguals working on that type of material translated. For instance, if a document had 60 phrases and six bilinguals translated all 60, the "total phrase" figure would be 360.

TABLE 3. TOTAL NUMBER OF ERRORS PER 100 WORDS AND NUMBER OF DIFFERENT ERRORS PER 100 WORDS*

Type of Material	No. of Errors* Per 100 Words	No. of Different Errors* Per 100 Words
UH-1H T.O. 12 translators 12 back-translators	5.5	5.0
	Based on 2400 words	
C-141A T.O. 6 translators 6 back-translators	6.9	4.6
	Based on 3486 words	
C-141A PIMO Aids 6 translators 6 back-translators	6.3	4.3
	Based on 3672 words	

*An error refers to a word or a series of words in the back-translation that is different from the original.

TABLE 4. PERCENTAGE OF ERRORS AND CORRECT TRANSLATIONS ANALYZED BY PHRASE FOR THE THREE TYPES OF TECHNICAL MATERIAL

Type of Material	Addition	Minor Omission	Major Omission	Garbling	Minor Substitution	Major Substitution	O.K.	Total No.
UH-1H T.O.	1.8	14.9	9.8	4.0	13.4	2.2	54.0	276
C-141A T.O.	1.5	10.1	2.5	2.3	31.7	6.0	45.9	397
C-141A PIMO Aids	2.1	10.9	6.1	1.9	30.3	5.1	43.6	376

The data in Table 2 are similar for all three types of technical material, especially the number of "different errors." The striking feature about the data in Table 4 is the similarity of the seven scores (six error and one "O.K.") for the C-141A T.O. and the C-141A

PIMO aids. In only one case is there more than a 2% difference between corresponding scores. The UH-1H T.O. "O.K." score of 54% is about 8% above the scores for the two C-141A materials, but this difference is not statistically significant ($p. > .10$). There are more major and minor omissions in the UH-1H T.O., but not a statistically significant ($p. > .10$) difference. One other difference worth noting is the greater number of minor substitutions in the UH-1H T.O. compared to the two materials for the C-141A. This difference is statistically significant ($p. < .05$).

The most striking feature of Table 4, the similarity of the seven scores for the C-141A T.O. and C-141A PIMO aids, fits in well with other findings which show that there is little or no difference in either speed or quality of translation for these materials. In the section on "translation speed" it was noted that bilinguals translate the PIMO aids and T.O. for C-141A with equal speed. In a following section it will be shown that Vietnamese Air Force enlisted men can answer questions about a mechanical system with equal accuracy whether they read the C-141A T.O. or the C-141A PIMO translation into Vietnamese.

The statistically significant difference in the number of substitutions contained in the UH-1H T.O. compared to the two C-141A materials deserves discussion. It must be remembered that the UH-1H materials were translated first. The bilinguals were learning unfamiliar material and made more errors of omission and garbling than they did later with C-141A materials. Errors of omission and garbling refer to places in the original that have either an absence of or an unintelligible corresponding phrase in the back-translation. While working later on the C-141A materials, they lessen these errors of omission and garbling but commit more errors of substitution in which there <u>is</u> a corresponding phrase in the back-translation. What may be happening in the later efforts, then, is that bilinguals are attempting more translations of difficult words, leading to substitution errors. They are doing this rather than not trying at all or making poor attempts, leading to omissions and garblings.

Procedures for Dealing With Unfamiliar Terms

Translators in out experiment did one of three things when they came across unfamiliar words in English or words for which there were no Vietnamese equivalents:

1. They left the English word intact in the translation; this is not a good solution because of low English comprehension levels among technicians,
2. They transliterated the word into Vietnamese (e.g., "piston" becomes "pít tông"),
3. They coined terms to describe, in a functional way, the English word or concept (e.g., "bypass valve" becomes "a valve used to pass fluids in the way not normally used.") This is the "explain around" technique, previously described.

QUALITY MEASURED BY KNOWLEDGE TESTING

In the knowledge testing technique, subjects read a translation and then answer a set of questions written about the passage. If the questions can be answered, the translation is assumed to be a good one. Knowledge test scores, based on different translations of the same original material, permit comparisons of translation quality.

Two knowledge testing experiments were run, each using different subjects and materials.

In the first experiment three translations of the same material from the Army's tech manual for the UH-1H helicopter were chosen that were thought to be of different quality. The quality ranking was based on the number of errors in the back-translation, the quality assessment procedure presented earlier. That is, translation A had fewer back-translation errors than translation B, and translation B had fewer errors than translation C. In addition, a Vietnamese linguist read the original English and the three translations, and then rank-ordered the translations from best to worst. His rank-ordering was the same as that based on the number of back-translation errors.

The knowledge test consisted of 10 questions written about the passage by the experimenters and translated into Vietnamese. Appendix B contains the passage and the 10 questions. The same 10 questions were to be answered after subjects read one of the three translations. Since the questions were the same, any differences in the number answered should be due to the quality of the translations.

Subjects were 68 Vietnamese Air Force enlisted men being trained in helicopter maintenance at Ft. Eustis, Virginia. These 68 subjects were asked to answer the 10 questions after being randomly assigned to read either translation A (N = 22 men), B (N = 23 men), or C (N = 23 men). Subjects had both the passage and the 10 questions in front of them throughout the one-half hour testing session so that memory was not a factor on this test.

The second experiment was designed to compare the answering of questions about translations of PIMO aids with those for the conventional USAF technical order for the C-141A aircraft. A single bilingual translated both the PIMO aids and the T.O. He alternated between sections of one document, then of the other, so that he would not translate one document better simply because he had practiced on the other.

The questions to be asked about the passages were translated into Vietnamese by the same bilingual. Six of the questions were the same for the T.O. and PIMO material since the same topic was covered in the passages under study. (Specifically, the topic was the maintenance of the normal and emergency brake system.) These six questions allowed a range of 0-21 points. The other questions, also representing 21 points, were different for the PIMO and T.O., i.e., they were unique to each passage. The "different" questions were added to increase the range of scores. An individual could thus achieve a score of 0 to 42. The major comparison between the PIMO and T.O. would be in the "same" questions since the same bilingual translated all test materials. Any differences in scores would be in the nature of the PIMO aids or the T.O.

Subjects were 36 Vietnamese Air Force enlisted men being trained in helicopter maintenance at Ft. Eustis, Virginia. They were asked to read either the PIMO or the T.O., and thus there were 18 subjects in a group. Subjects had both the passage and questions in front of them for the one-half hour testing session. All tests, in both experiments, were scored by a Vietnamese linguist.

Findings

Table 5 gives the results of both knowledge testing sessions. For session 1, where a perfect socre is 10, it can be seen that subjects were able to answer more questions about translation A than B, and more about B than C. This rank-ordering is the same as that found by errors in the back-translation and by the judgments of a Vietnamese linguist. Differences among all combinations of the three means (A versus B, A versus C, B versus C) are statistically significant ($p. < .01$). These results show that the knowledge test is sensitive enough to demonstrate differences in translation quality.

TABLE 5. TRANSLATIONS EVALUATED BY KNOWLEDGE TESTING: TWO EXPERIMENTS

Translation	No. of Subjects	Mean Score	Standard Deviation
Experiment 1: Comparison of three translations of UH-1H TM			
A	22	6.1	2.2
B	23	4.3	1.8
C	23	2.6	1.3
Experiment 2: Comparison of PIMO and T.O. translations for C-141A			
PIMO			
Total score		34.8	3.3
Same questions		16.2	3.7
Different questions	18	18.6	1.2
T.O.			
Total score		33.2	6.7
Same questions		16.1	2.9
Different questions	18	17.1	4.7

For session 2, the data toward the bottom of Table 5 show that the translation of the PIMO aids and the T.O. for the C-141A allow the same number of both the same (perfect score is 21) and different (perfect score is 21) questions to be answered. Thus the total number of questions (perfect score is 42) are also the same for the T.O. and PIMO aids. The very small differences are <u>not</u> statistically significant ($p. > .10$).

Two points can be noted on the basis of the knowledge testing.

1. The rank ordering of translation quality according to the knowledge test is the same as that derived from comparisons of the original and back-translation. The latter method, however, is less expensive and less time consuming, since a researcher does not have to gather subjects to respond to a knowledge test. There is, of course, a trade-off between confidence in the methods and cost. Back-translation is less expensive but does not provide as much confidence in quality assessment as knowledge testing. Both knowledge testing and the original back-translation comparison method seem sensitive enough to differentiate among translations of unequal quality. Note that both the knowledge testing and the back-translation comparison methods allow a person who doesn't speak Vietnamese to evaluate translation quality.

2. There seems to be no difference between translations of the T.O. for the C-141A and the PIMO aids as shown by the knowledge test. The translation speed scores and translation quality scores (through back-translation comparison) also showed no differences. Thus, the PIMO type of format offers no advantages in translatability over the conventional T.O.

RELATION BETWEEN TRANSLATION SPEED AND QUALITY

Translation speed and translation quality have been dealt with separately in previous sections. In this section we would like to

summarize our inquiry into whether or not there is any relation between speed and quality. That is, if a translator is fast, can we predict how good his translation will be? Or, if he translates with few errors, can we predict how fast he works?

Correlations were computed comparing the number of errors found by comparing the original against the back-translation and several indices of speed. Several speed indices were necessary since the back-translation product is due to two efforts: (1) the original to the translation step, and (2) the translation to the back-translation step. Each of these two steps has a corresponding speed score. The three indices of speed were:

1. speed of the original to the translation step
2. speed of the translation to the back-translation step
3. average speed involved in the two steps

The first index, speed of the original to the translation step, is most important for the analysis of a speed-quality relation, and the other two indices are clearly of less practical significance. The other speed indices, however, were compared with the quality score to examine the relation in more depth. Each of the three speed indices was compared to the back-translation error score for each of the three types of technical material. Thus, there were nine correlation coefficients: three for the UH-1H T.O., three for the C-141A T.O., and three for the C-141A PIMO aids.

The correlation coefficient used was the Spearman Rank Correlation Coefficient (Siegel, 1956, pp. 202-213). A Spearman coefficient of 1.00 would show perfect correlation between speed and quality (the fastest are the best and the slowest are the worst). A coefficient of -1.00 would show perfect agreement in the negative direction (the fastest are the worst and the slowest are the best). A coefficient of 0 (zero) would show no relation between speed and quality.

Findings

The range of the nine correlation coefficients, all shown in Table 6, was r = -.88 to r = .50. The only statistically significant coefficient of the nine was the r = -.88 figure. There is an indication that conventionally written technical material for the C-141A tended to be translated more accurately by the slower translators and, conversely, the faster translators were less precise.

TABLE 6. CORRELATIONS BETWEEN SPEED AND QUALITY FOR TRANSLATIONS AND BACK-TRANSLATIONS

	Type of Technical Material		
Translation Step	UH-1H T.O.	C-141A T.O.	PIMO for C-141A
Speed of Original to Translation	-.20	-.88	.23
Speed of Back-Translation to Translation	.50	.09	.09
Average Speed (Combined Forward and Back-Translation)	-.21	-.60	.14

With that one exception there seems to be little relation between translation speed and translation quality. Whether a translator is fast or slow, we can tell little about the quality of his translations. Likewise, whether his translations are of good or bad quality (as shown by back-translation error scores), we can tell very little about his speed. The factors of translation speed and of translation quality seem to be independent. Perhaps the independence between speed and quality reflects the restricted range of translator ability. If a wider range of skill were sampled a speed-quality relation might be demonstrated.

QUALITY MEASURED BY PERFORMANCE TESTING

Although it is a much more expensive and time-consuming approach to evaluating translations, the technique of observing men work with translated material comes closer to an ultimate criterion of the value of translations than any other method. In addition to being slower, the administration of performance tests yields relatively less data than the other techniques we have used. But, the technique is attractive because it provides straight-forward information that is easy to interpret: men do a task which is dependent on written material and their performance is objectively scored. Good performance means that the writing was useful and vice versa. In our experiments, teams of technicians carried out a very demanding adjustment task on a portion of the UH-1H helicopter main power plant.* Observers, U.S. Army sergeants who were both experts in helicopter maintenance and instructors on the system to be adjusted, assessed each of 12 steps in the task as "Error free", "Minor performance error", or "Major error." "Minor errors" were those steps that the crews did wrong, but then corrected themselves; "major errors" were noted if crews did not know how to proceed or if their performance was so far off that it required intervention by the observers.

In addition to error scores, we recorded the time taken by each crew to do the 12 steps in the adjustment task. (In one translation condition, in which major errors were frequent, time measurement became impossible because the observers had to step in often to assist the crews.)

There were four experimental language conditions: (1) the standard or original English technical manual; (2) a very high quality translation, and (3) and (4), two lesser grades of translation. The high quality translation was produced as follows: two of our best translators each worked independently, then they reviewed each other's work

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*Sect. 5-391 "Adjustment--Power Turbine Governor RPM Controls," U.S. Army Tech Manual TM-55-1520-210-20. (See Appendix A for English and Vietnamese texts.)

and wrote a "consensus" translation. Finally, our linguist consultant reviewed and modified their combined effort. The translators had available two bilingual glossaries of technical terms, i.e., helicopter and automotive.* (We refer to this translation as "supervised.")

The first of the lesser quality translations was done by a free-lance, highly qualified translator to whom we gave copies of the same technical glossaries mentioned above. This man was paid a fixed fee and he worked without review. (We call this the "free lance translation.") The second of the lesser quality translations was obtained by contracting with a Washington translation services company for a fixed fee to have the approximately 1000 words of English translated. We had no control of the method used by the translator nor did he have access to any glossaries or other aids. Since he was paid a fixed fee, we assume the translator worked as fast as possible. His work was not reviewed. (We call this the "commercial translation.") It is important to note that both the free lance and commercial translators were highly qualified translators, each being a member of the staff of the Voice of America. (Appendix A contains copies of the original English corpus and the best translation.)

Crews used as subjects were assembled from two groups of men at the U.S. Army's Transportation School, Ft. Eustis, Virginia: (1) Vietnamese airmen who had just completed the Army's aircraft maintenance and helicopter repairman courses, and (2) U.S. Army enlisted technicians who were also newly graduated from the same courses. Vietnamese airmen were assigned randomly to one of the four language conditions. Four classes of VNAF airmen furnished subjects and we have assumed that there were no qualitative differences among or between these groups. In each language condition shown there were six three-man crews, each of which worked independently.** The American Army technicians, who worked in English, are included for comparison.

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* Ft. Eustis, Virginia, 1969; Training Aids Division, 1967.

** Data for one crew, commercial translation, were lost because that crew was unable to follow the translation.

Findings

Table 7 illustrates several striking things about translated technical material.

TABLE 7. PERFORMANCE TEST RESULTS: ACCURACY

Experimental Condition	Error Free, %	Major Errors Committed, %
Vietnamese: Supervised Translation	73.1	5.6
Vietnamese: Free-Lance Translation	40.3	4.2
Vietnamese: Commercial Translation	11.0	37.0
English (VNAF Subjects)	40.7	20.6
English (U.S. Army Subjects)	73.2	0.0

First, it is clear that working in one's own language, even in translation, is significantly better than having to use a second language. The difference is significant by chi-square at less than the .01 level. However, an important qualification is that a translation must be high quality. Second, the performance task is sensitive to the quality of translation: commercial quality produced much higher rates of serious errors than the English text. That is, the Vietnamese airmen worked more effectively with English than they did using a poor translation ($p. < .05$). Third, the quality of translated technical documents, as measured by performance, is directly influenced by the procedures of the translators. Thus, using a group of men who were approximately equal in their bilingual abilities as translators we were able to produce very different levels of material. The mode of compensation, i.e., placing a premium on speed, was one procedural variable. The availability of bilingual glossaries of technical terms was another, and probably the most important, reason. Incorporation of team translation and a review procedure seemed to make a difference. Fourth, the careful translation procedures outlined here can lead to

documents that allow Vietnamese mechanics to perform as well as U.S. Army mechanics.

As an example of what can happen to less than thorough translation, a partial analysis of the commercially prepared document showed at least two serious errors: (1) an entire sentence was omitted from one paragraph; and (2) the translator substituted "...British centimeters..." for the correct "...inches..." each time a measurement dimension was given.

Where it was possible to make measures of time required for the performance task, working in a familiar language was advantageous (Table 8). While it is clear that the VNAF subjects working in Vietnamese spent less time than when they worked in English, the time measures within the three Vietnamese translation conditions do not lead to straight-forward interpretation.

TABLE 8. PERFORMANCE TEST RESULTS: SPEED

Experimental Condition	Mean Time, Minutes
Vietnamese: Supervised Translation	37
Vietnamese: Free-Lance Translation	27
Vietnamese: Commercial Translation	*
English (VNAF Subjects)	45
English (U.S. Army Subjects)	22

*Excessive error rate precluded making meaningful measures.

SUBJECTIVE OPINIONS AND TRANSLATION QUALITY

An interesting fact emerged from discussions with some of the Vietnamese airmen who used the best translated material. Most of the men we talked with after they had worked on the performance task expressed a dislike for the translations. The principal objection seemed to be that there were unfamiliar Vietnamese terms used for some of the technical English words. To paraphrase the words of some subjects, "...we did not understand all the Vietnamese words. We would prefer to use the English manual on which we had been trained." It is particularly noteworthy that, in spite of their expressed dislike of even the best quality translation, the measured performance of these airmen was nearly equal to that of the American technicians. Similarly, we asked two bilingual readers (one of whom was an expert in helicopter maintenance) to review and comment on one of the unaided commercial translations. Both of these men thought that the document was "pretty good." However, in practice, it produced the worst performance of any of the language conditions. The point we wish to underscore is the discrepancy between subjective assessment and performance testing as ways of evaluating translations. The verbal reactions of our subjects and of the linguists were reversed when we went to performance observations, as shown in Table 9.

TABLE 9. ASSESSMENT OF TRANSLATIONS: SUBJECTIVE OPINION VERSUS PERFORMANCE

Subjective Opinion	Performance
VNAF - "Don't like translation"	Very Good
Bilingual reviewers - "Not bad"	Poor

Clearly, subjective opinion and performance do not predict the same thing and we strongly endorse the latter method as the more valid way to test translations.

V. COST OF TRANSLATION

Not only are skillful translators in short supply, but their services are expensive. We paid each of our 12 Vietnamese translators $8.00 per hour. At a daily rate, and assuming productivity of 2400 words of technical material processed per day by a single translator, 1000 words of English-to-Vietnamese would cost about $27.00. This figure does not include review or other quality control costs or overhead.

Commercial translation services are available, but are in very limited supply for technical material. The free-lance translation and the commercially supplied translation (used in the performance test) cost $30 to $39, respectively, for just under 1000 words. Again, neither of those products was reviewed for accuracy.

Some data are available on translation costs for languages other than Vietnamese. Based on a 1965* analysis of the USAF Foreign Technology Division's experience with translating scientific Russian to English, 1000 words cost about $40. This is based on an in-house, i.e., Civil Service, translation staff and about 60% of the figure goes to salaries. Since the average middle grade pay has increased approximately 75% since the Pierce Committee's report, a reasonable current estimate would be about $60 per 1000 words of scientific Russian.

We believe that the costs incurred in the present study for the best quality translation, i.e., $140 per 1000 words, could be reduced

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*Pierce, J.R., et al., "Language and Machines," National Academy of Sciences, Washington, D.C., 1966.

by about half. The means for achieving a lower rate are beyond the scope of this study but we suggest, tentatively, that the following steps would serve to provide a high quality, reasonably priced English-to-Vietnamese translation service: (a) compensate translators on a piece rate basis but insist on quality work; (b) spot check quality via one or more of the techniques described in earlier sections of this report (e.g., back-translation or knowledge testing*) and adjust compensation to the results of the quality check; (c) always have every translation reviewed by the best available bilinguals; (d) develop and provide bilingual technical glossaries covering the substantive areas being translated; (e) when feasible, try to provide some technical indoctrination for translators such as a brief orientation course, demonstrations of the equipment, and so on.

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*Performance testing is too expensive to be used as a regular control.

VI. WRITING TRANSLATABLE ENGLISH

Having demonstrated some of the errors that occur in translation, we asked, "Can the original technical English be written so that it is more easily (i.e., accurately) translated?" To provide tentative answers, the back-translations of 12 Vietnamese bilinguals were investigated in order to see what problems they encountered. If certain aspects of the original English (such as the use of long sentences) often caused translation problems, it could be assumed that these aspects should be changed in order to secure good translations in the future. Each time there was an error in the back-translation, we looked at the original English to decide what caused the poor translation. Perhaps the problem was long sentences. If the monolingual finds that the same aspect, long sentences, causes errors in different parts of the original English text and causes errors by different translators, then he can assume with some confidence that the aspect does indeed cause poor translations.

This method of examination was applied to the 9558 words translated and back-translated by the 12 Vietnamese bilinguals. Eight aspects of the original English seemed to cause problems, and these problems can be alleviated by rewording the English. The findings permit a list of rules for writing translatable English to be formed.

Based on our analysis of back-translations, the following rules for writing translatable English can be suggested. All examples are from the corpus described in Chapter III, "Methodology."

1. Use short sentences of less than 16 words. Our analysis demonstrated that sentences of more than 16 words translated poorly.

2. Separate nouns rather than string them together. It is wrong to write such phrases as: "organizational maintenance activities"; "low oil pressure indication"; "ground safety pins"; "trouble-shooting precautions."

3. Use the active rather than the passive voice. Several passive voice forms that were poorly translated are: "will not be shown by; must be installed."

4. Write words completely rather than abbreviate. These abbreviations led to confusion: "D.C., Landing Gear Cont."

5. Avoid adverbs and prepositions telling "where" or "when" if possible. These prepositions and adverbs were poorly translated: "reasonably probable"; "frequent"; "beyond"; "upper."

6. Avoid possessive forms where possible. Examples are: "systems and components of power train"; "dust caps from ends of tester hose."

7. Use one-syllable rather than poly-syllabic modifiers where possible. Examples of poorly translated poly-syllabic modifiers are: "indicated oil pressure"; "unusual chain of events."

8. Use specific terms rather than vague words. These vague words were poorly translated: "properly serviced"; "install" (how install?); "fluid" (what kind of fluid?).

Several phrases in the corpus were translated perfectly by all bilinguals. A few of these will be listed. Note how they follow the above rules almost perfectly.

1. "This chapter provides all the instructions and information."

2. "Effects of an oil leak will depend on its location in system and rate of leakage."

3. "Man A and Man B should be in communication with each other during the test."

4. "Open each valve, observing the sight gage until sight gage is free of air bubbles, then close." (NOTE: The redundancy of using "sight gage" twice is good practice in writing translatable English.)

One phrase was translated very badly by all bilinguals. The rules this phrase breaks are noted in parentheses.

> Install the pilot's and copilot's (rule 6) rudder pedals behind (rule 5) the rudder tension regulator (rule 2)."

Finally, certain aspects of the PIMO materials in their present form translated well.

1. The command form of the verb in the PIMO aids provided good translations, e.g., "place short tester hose"; "repeat for all upper valves."

2. When the other eight rules were followed, the short sentences in the PIMO aids translated well.

We suggest that the foregoing rules, applied to manuals in the English language and intended for use by U.S. military personnel, will improve their readability as well.

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APPENDIX A

UH-1H TECHNICAL MANUAL
(TM-55-1520-210-20), Section 5-391

and

BEST VIETNAMESE TRANSLATION
(Referred to in Text as "Supervised Translation")

NOTE: Steps b. through m. formed the performance test reported in this paper.

5-391. ADJUSTMENT - POWER TURBINE GOVERNOR RPM CONTPOLS.

a. Be sure collective pitch control system rigging has been completed.

b. Lock collective pitch control stick in full down position and adjust droop compensator control tube (2, figure 5-77) to align center of bolt hole in aft arm of torque tube (4) approximately level with top of support bracket (11). Due to shimming, manufacturers tolerance, etc., variation of 0.250-inch from top of support bracket is possible and acceptable. (See detail B.)

c. Set cam adjustment (15) to middle of slot. (See detail D.)

d. Move collective pitch control stick to full up position and lock.

e. Adjust control rod (12) attached to cam bellcrank so that approximately 0.25-inch of cam slot is visible below cambox housing for T53-L-9, -9A, -11, and -11B engines; 0.38-inch for T53-L-13 engines.

This is a nominal setting and is subject to change, if necessary, in following steps.

f. Check installation of governor control lever (17) as nearly at 90 degree angle to stop arm as serration alignment permits. (Refer to paragraph 5-386 step a.)

g. Adjust upper governor stop screw to 0.250-inch for T53-L-9 and -9A engine; 0.210-inch for T53-L-11, -11B, and -13 engines, measured from inner side of mounting boss. (See detail C.) Remove and discard lead seal on lockwire, if existing.

Note

Never shorten either stop screw on governor to less than 0.060 inch length from inner side of boss.

h. Disconnect actuator shaft from governor control lever (17) by removing bolt.

i. Electrically position actuator shaft to approximate midpoint of stroke.

(1) If actuator with two adjusting screws is installed, turn both positive stop adjusting screws to obtain maximum stroke (see detail E). Reduce stroke by turning each screw ten full turns away from maximum adjustment to obtain actuator nominal position.

(2) If actuator with single adjusting screw is installed it is not necessary to adjust positive stop screw to obtain nominal position. Positive stops can be adjusted, if necessary, for travel of 0.500 inch to 1.75 inch without change in nominal position.

Note

One full turn of the adjusting screw will cause a change in both the retract and extend position of .032 inch. (See detail E.)

Note

Set actuator travel to: 1.38-inch for T53-L-9, -9A engines; 1.25-inch for T53-L-11 series engines; 1.20-inch for T53-L-13 engine.

j. Fully retract actuator shaft by holding GOV RPM switch to INCR. Move collective stick to full up position.

k. Reinstall bolt connecting actuator to governor control lever, adjusting actuator shaft rod-end to obtain 0.010 inch clearance between governor stop arm and upper stop screw, measured with a feeler gage. (See detail C.) If necessary, reposition control lever one serration on governor shaft to accomplish this adjustment while keeping safe thread engagement of rod-ends.

Note

When tightening jamnut on actuator shaft, center rod-end in clevis of lever so that self-aligning bearing will absorb any rotation of shaft.

l. Fully extend actuator shaft by holding GOV RPM switch to DECR. Lock collective pitch control stick in full down position.

m. Adjust lower stop screw for 0.010 inch clearance with governor stop arm, measured with a feeler gage. Remove and discard lead seal on lockwire, if existing. Observe minimum length limitation. (Refer to Note under step g.)

n. On initial ground run, with collective pitch control stick full down, check for 6000 to 6700 (±50) rpm range controlled by GOV RPM switch. If necessary, readjust actuator stroke length to obtain required range, repeating clearance checks and adjustment at both governor stop screws.

o. Make final adjustments of droop compensator cam as required by flight checks. Set cam to maintain 6600 nII rpm (plus or minus 40) from full low pitch to full power. If rpm droop occurs, rotate cam counterclockwise toward maximum compensation. If maximum compensation adjustment does not correct droop, lengthen control rod (12) to increase amount of cam slot showing below housing. Be sure roller does not bottom out at end of cam slot in either extreme of travel.

Note

Readjust governor stop screws for clearance after any change in rigging.

5-386. INSTALLATION - ACTUATOR AND CONTROL LEVER.

a. Place control lever (17, figure 5-77) on governor control shaft (18) as nearly at 90 degree angle to centerline of shaft stop-arm (19) as serrations permit. Install retaining bolt, with washer, from aft side into lever and through shaft groove. Lock-wire bolt head to shank of lever.

1. Collective Pitch Bellcrank
2. Control Tube
3. Bracket Assembly
4. Torque Tube
5. Shear Fitting
6. Bellcrank
7. Shear Pin
8. Shims
9. Retaining Washer
10. Firewall Seal
11. Support
12. Control Rod
13. Cambox Bracket
14. Cambox Assembly
15. Cam Adjustment
16. Linear Actuator
17. Control Lever
18. Governor Control Shaft
19. Shaft Stop-Arm
20. High RPM Stop
21. Low RPM Stop

205060-10D

Figure 5-77. Power turbine governor rpm controls (Sheet 1 of 2)

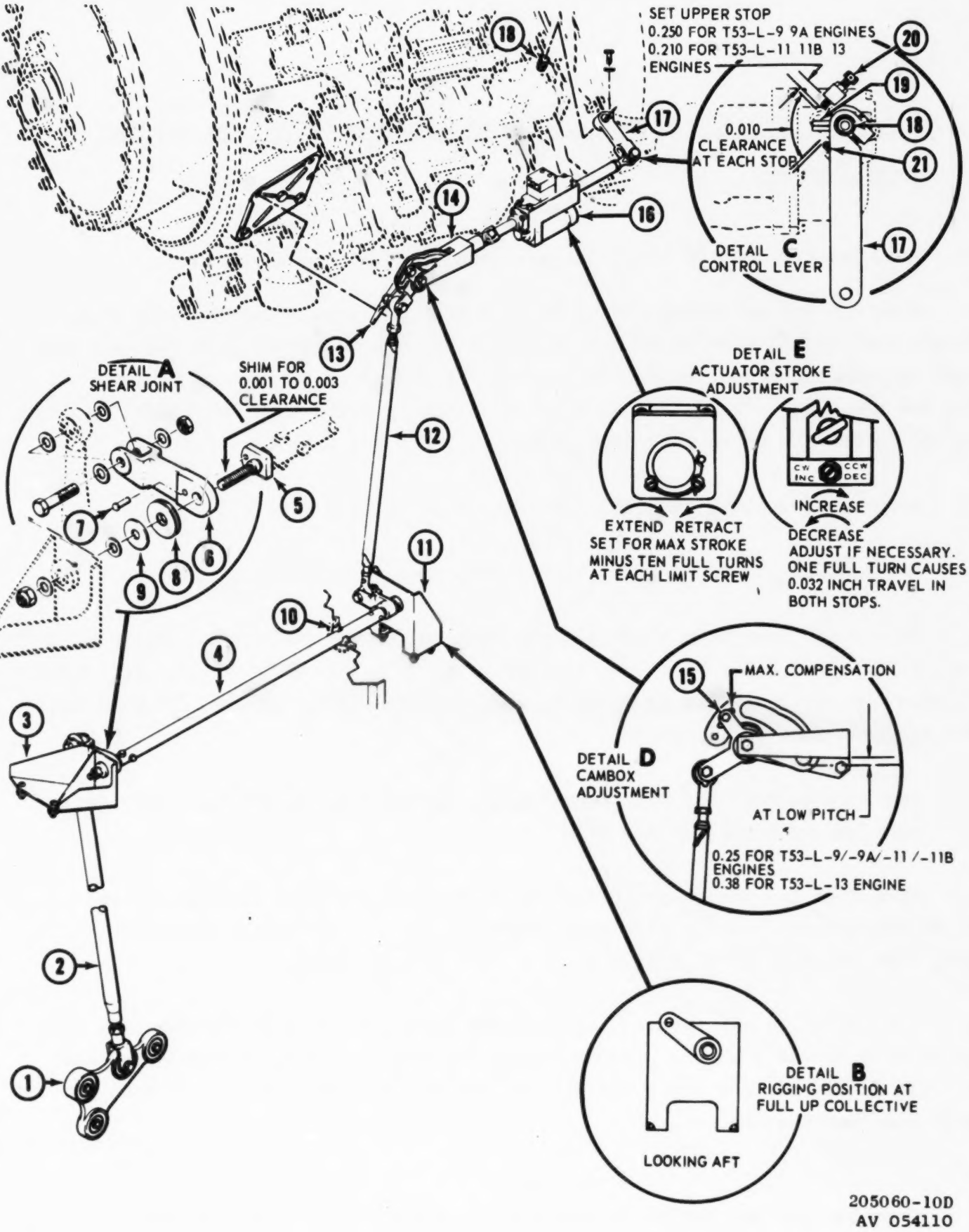

SET UPPER STOP
0.250 FOR T53-L-9 9A ENGINES
0.210 FOR T53-L-11 11B 13 ENGINES
0.010 CLEARANCE AT EACH STOP
DETAIL C CONTROL LEVER
DETAIL A SHEAR JOINT
SHIM FOR 0.001 TO 0.003 CLEARANCE
DETAIL E ACTUATOR STROKE ADJUSTMENT
CW INC
CCW DEC
INCREASE
EXTEND RETRACT
SET FOR MAX STROKE MINUS TEN FULL TURNS AT EACH LIMIT SCREW
DECREASE
ADJUST IF NECESSARY. ONE FULL TURN CAUSES 0.032 INCH TRAVEL IN BOTH STOPS.
MAX. COMPENSATION
DETAIL D CAMBOX ADJUSTMENT
AT LOW PITCH
0.25 FOR T53-L-9/-9A/-11/-11B ENGINES
0.38 FOR T53-L-13 ENGINE
DETAIL B RIGGING POSITION AT FULL UP COLLECTIVE
LOOKING AFT
205060-10D
AV 054110

Figure 5-77. Power turbine governor rpm controls (Sheet 2 of 2)

5-391 Cach Diều Chỉnh - Bộ Phận Điều Khiển Vòng Quay Bố Tiết Chế Máy Phát Lực Tua-Bin

a. Kiểm lại cho chắc hệ thống dổi sải chung đã được ráp xong.

b. Khoá cần dổi sải chung vào vị trí cao nhất, và diều chỉnh ống diều khiển bổ bổi hoàn/(2, hình 5-77) dể sửa cho trung tâm của lỗ bu-lon ở tay sau của ống soàn (4) gần cao ngang với đỉnh của giá đỡ (11). Nhờ có lá chềm và độ dung sai của nhà sản xuất, vân vân... nên sự xê dịch khoảng 0.250 phân Anh (inch) tử đỉnh giá đỡ có thể xảy ra và cũng chấp nhận được. (Coi chi tiết B)

c. Xoay bộ diều chỉnh cam (15) vào chính giữa lỗ mộng (Coi chi tiết D)

d. Kéo cần dổi sải chung xuống vị trí thấp nhất và khóa lại.

e. Diều chỉnh then điều khiển(12) gắn liền với tay chuyền lực cam dể khoảng 0.25 phân Anh của lỗ mộng cam này ở phía dưới hộp dĩa cam cho các loại động cỏ T53-L-9, -9A, -11, và -11B ; khoảng 0.38 phân Anh cho các loại dộng cỏ T53-L-13.

Trên đây là cách sắp dặt thông thường, và nếu cần, có thể được thay dổi theo các bước chỉ dẫn sau đây:

f. Kiểm diểm lại việc ráp cần điều khiển bộ tiết chế (17) có đúng gần góc 90 độ dối với tay hãm . việc điều chỉnh sụ của đường răng của cho phép (Coi lại đoạn 5-386 bước a.)

g. Điều chỉnh ốc hãm trên của bộ tiết chế khoảng 0.250 phân Anh cho loại động cỏ T53-L-9 và -9A ; khoảng 0.210 phân Anh cho các loại dộng cỏ T53-L-11, -11B và -13, đo tử phía bên trong của lỗi gắn trở ra (Coi chi tiết C). Tháo bỏ kẹp chì trên giây kềm hãm, nếu có.

GHI CHÚ

Dùng bao giờ vặn bất cứ ốc hãm nào trên bộ tiết chế xuống quá mức 0.060 phân Anh kể tử phía trong lỗi gắn trở ra.

h. Tách trục tác động khỏi cần điều khiển bộ tiết chế (17) bằng cách tháo bỏ bù-lon

i. Dùng điện xoay trục tác động vào vị trí gần đúng trung điểm của thì chuyển động

(1) Nếu xử dụng bộ tác động có 2 ốc điều chỉnh, thì vặn cả 2 ốc hãm điều chỉnh dương để có được thì chuyển động tối đa(coi chi tiết E). Hãy giảm thì chuyển động bằng cách vặn ngược mỗi ốc hãm 10 vòng khỏi vị trí điều chỉnh tối đa để có được vị trí tác động thông thường.
(2) Nếu xử dụng bộ tác động có một ốc điều chỉnh thì khởi cần phải điều chỉnh ốc hãm điều chỉnh dương để có vị trí thông thường. Nếu cần, các nấc hãm dương có thể được điều chỉnh để di chuyển trong vòng 0.500 phần Anh đến 1.75 phần Anh mà không cần phải thay đổi vị trí thông thường.

GHI CHÚ

Một vòng xoay của ốc điều chỉnh sẽ làm thay đổi cả vị trí thu hẹp và nới rộng khoảng 0.032 phần Anh (coi chi tiết E)

GHI CHÚ

Điều chỉnh khoảng di chuyển bộ tác động như sau: 1.38 phần Anh cho các động cơ T53-L-9 và -9A ; 1.25 phần Anh cho loạt động cơ có số loại T53-L-11 ; và 1.20 phần Anh cho động cơ T53-L-13.

j. Thu hẹp trục tác động hãn lại bằng cách giữ công-tắc tăng giảm vòng quay bộ tiết chế ở vào vị trí TĂNG (INCR). Đây cần đối cãi chung lên vị trí cao nhất.

k. Gắn lại cây bù-lon nối bộ tác động vào cần điều khiển bộ tiết chế, điều chỉnh đầu trục quay bộ tác động để có được khoảng cách 0.010 phần Anh giữa tay hãm bộ tiết chế và ốc hãm trên, và đo khoảng cách này bằng thước đo khe hở. (Coi chi tiết C) Nếu cần, đặt lại vị trí cần điều khiển sang một nấc răng của ở trên trục quay bộ tiết chế để hoàn tất việc điều chỉnh này, mà vẫn giữ cho việc ăn khớp của chi ốc ở hai đầu trục được an toàn.

GHI CHÚ

Khi xiết chặt ốc chân trên trục tác động, hãy đặt đầu trục vào giữa chĩa của cần điều khiển để cho ổ bạc đạn tự chỉnh có thể chịu đựng được mọi hướng quay của trục.

l. Nới rộng hãn trục tác động bằng cách giữ công-tắc tăng giảm vòng quay bộ tiết chế ở vào vị trí GIẢM (DECR). Khóa cần đổi sãi chung vào vị trí thấp nhất.

m. Điều chỉnh ốc hãm phía dưới để có khoảng trống 0.010 phần Anh đối với tay hãm bộ tiết chế, và đo khoảng cách này bằng thước đo khe hở. Tháo bỏ kẹp chì trên giây kẽm hãm , nếu có. Hãy tôn trọng giới hạn tối thiểu về chiều dài (coi ghi chú ở bước g.)

n. Khi cho chạy thử lúc đầu ở dưới đất và để cần đổi sãi chung ở vị trí thấp nhất, hãy kiểm điểm tầm quay từ 6000 tới 6700 RPM (+ hay- 50) do công tác tăng giảm vòng quay bộ tiết chế chi phối. Nếu cần, điều chỉnh lại thì chuyển động của bộ tác động để có được tầm quay cần thiết, đồng thời kiểm điểm lại khoảng cách và điều chỉnh cả hai ốc hãm bộ tiết chế.

o. Điều chỉnh lần chót dĩa cam của bộ bồi hoàn giảm tốc theo quy luật phi hành. Điều chỉnh cam để có thể duy trì tầm quay 6600 nII RPM (+ hay - 40) khi chuyển từ sãi thấp nhất tới tốc lực cao nhất. Nếu số vòng quay mỗi phút bị giảm đi, hãy vặn dĩa cam ngược chiều kim đồng hồ về phía độ bồ chỉnh tối đa. Nếu việc điều chỉnh lại độ bồ chỉnh tối đa vẫn chưa được sự giảm tốc độ, hãy kéo dài then điều khiển (12) để gia tăng phần lồ mộng dĩa cam nhìn thấy ở phía dưới hộp đựng. Hãy cẩn thận đừng để cho con lăn thoi đầu ra ở cuối lồ khía dĩa cam mỗi khi di chuyển hãn về phía bên này hay phía bên kia.

GHI CHÚ

Hãy điều chỉnh lại các ốc hãm bộ tiết chế để có được khoảng cách cần thiết sau mỗi lần thay đổi trong việc ráp nối hệ thống.

Translators' Coined Terms .

Collective pitch control	: hệ thống đổi sãi chung
Droop compensator	: bộ bồi hoàn giảm tốc
Governor	: Bộ tiết chế
Stop Arm	: Tay Hãm
Actuator	: Bộ tác động
Stroke	: thì chuyển động
Travel	: khoảng di chuyển
Feeler gage	: thước đo khe hở
Jam nut	: ốc chận
Clevis	: nạng, chĩa

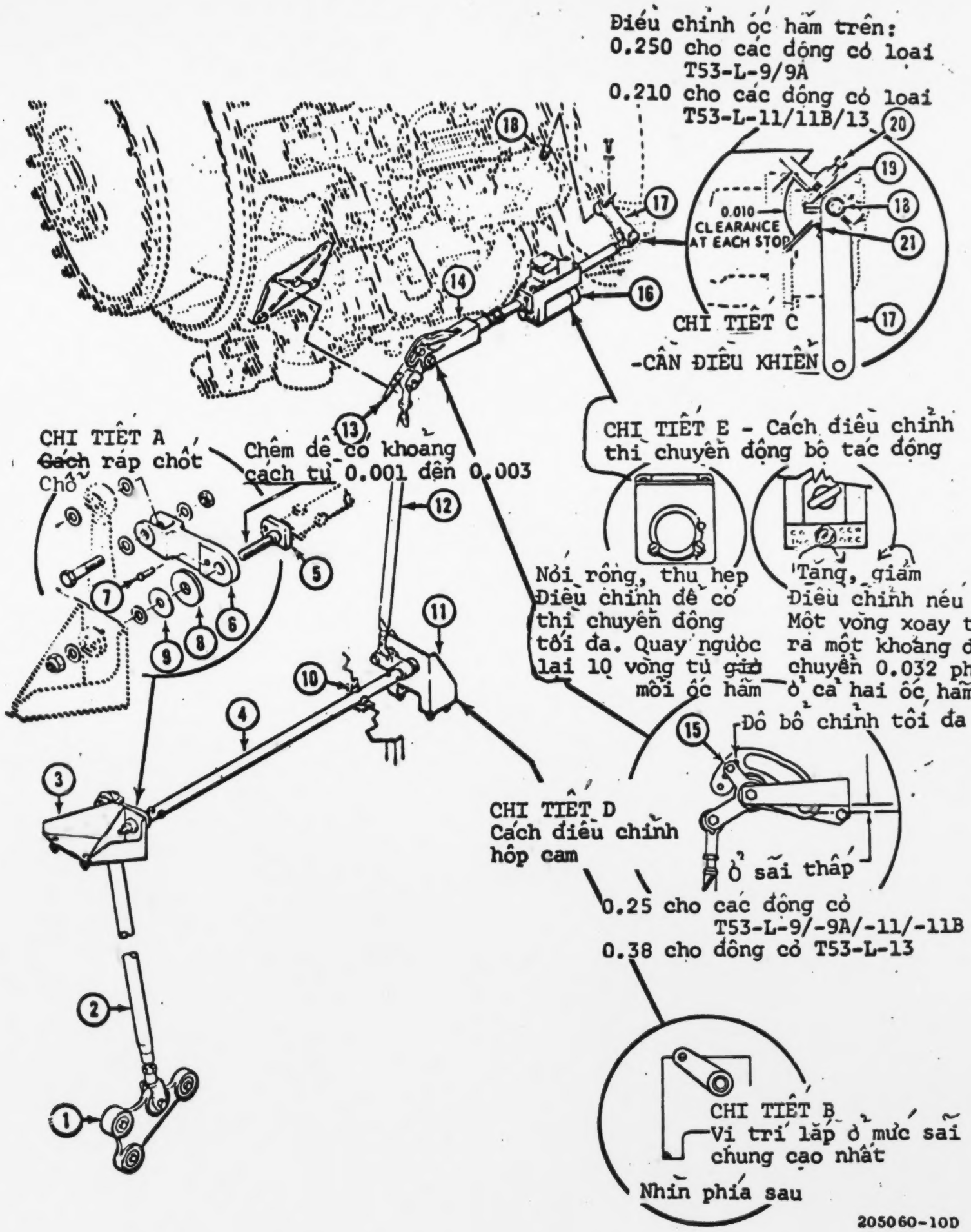
Positive stop adjusting screw	: ốc hãm điều chỉnh dưỡng - cực
self aligning bearing	: bạc đạn tự chỉnh
retaining bolt	; bu-lon hãm
Firewall seal	: vành che ngăn lửa
Shear fitting	: cơ phận ráp khít
Shear joint	: cách ráp chốt

5-386 CÁCH LẮP RÁP - BỘ TÁC ĐỘNG VÀ CẦN ĐIỀU KHIỂN

a. Đặt cần điều khiển (17, hình 5-77) lên trục điều khiển bộ tiết chế (18) tới góc gần sát 90 độ đối với đường vạch giữa của tay hãm trục (19) tới mức đường răng của cho phép. Lắp bù-lon hãm với vòng chêm từ phía sau vào cần điều khiển và xuyên qua đường soi của trục. Dùng giây kẽm khóa đầu bù lon vào đầu cần điều khiển.

Hình 5-77

1. Tay truyền lực sai chung
2. Ống điều khiển
3. Bộ giá lắp
4. Ống soán
5. Cờ phân rạp khít
6. Tay truyền lực
7. Chốt ~~an toàn~~ để cắt
8. Lá chêm, vòng chêm
9. Vòng đệm hãm
10. Vành che ngăn lửa
11. Giá đỡ
12. Then điều khiển
13. Mâu gắn hộp cam
14. Toàn bộ hộp cam
15. Điều chỉnh đĩa cam
16. Bộ tác động có trục chạy theo đường thẳng
17. Cần điều khiển
18. Trục điều khiển bộ tiết chế
19. Tay hãm trục
20. Ốc hãm độ quay trên
21. Ốc hãm độ quay dưới


Điều chỉnh ốc hãm trên:
0.250 cho các động cơ loại T53-L-9/9A
0.210 cho các động cơ loại T53-L-11/11B/13
0.010 CLEARANCE AT EACH STOP
CHI TIẾT C
-CẦN ĐIỀU KHIỂN
CHI TIẾT A
Cách ráp chốt Chữ
Chêm để có khoảng cách từ 0.001 đến 0.003
CHI TIẾT E - Cách điều chỉnh thi chuyển động bộ tác động
Nới rộng, thu hẹp Điều chỉnh để có thi chuyển động tối đa. Quay ngược lại 10 vòng từ giữ mỗi ốc hãm
Tăng, giảm Điều chỉnh nếu cần. Một vòng xoay tạo ra một khoảng di chuyển 0.032 phần Anh ở cả hai ốc hãm
Đo bề chỉnh tối đa
CHI TIẾT D
Cách điều chỉnh hộp cam
ở sai thấp
0.25 cho các động cơ T53-L-9/-9A/-11/-11B
0.38 cho động cơ T53-L-13
CHI TIẾT B
Vị trí lắp ở mức sai chung cao nhất
Nhìn phía sau
205060-10D
AV 054110

Hình 5-77. Bộ phận điều khiển vòng quay, bộ tiết chế máy phát lực tua-bin (Tờ 2 của 2 trang)

APPENDIX B

KNOWLEDGE TEST MATERIALS

CHAPTER 7

POWER TRAIN SYSTEM

SECTION I SCOPE

7-1. PURPOSE.

7-2. This chapter provides all the instructions and information necessary for maintenance authorized to be performed by organizational maintenance activities on the power train system. The power train is a system of shafts and gear boxes through which the engine drives main rotor, tail rotor, and accessories such as DC generator and hydraulic pump. The system consists of a main drive shaft, a main transmission which includes input and output drives and the main rotor mast, and a series of drive shafts with two gear boxes through which the tail rotor is driven. (See figure 7-1.)

7-3. TROUBLESHOOTING - POWER TRAIN.

7-4. Chart below is a brief summary of power train troubles which may be encountered in organizational maintenance. Conditions and possible causes listed have been limited to those reasonably probable (though not necessarily frequent in normal service) which could become known through pilot reports or by inspection methods applicable in organizational maintenance, and which would be subject to some evaluation at this level, although final corrective action by a higher level might be required in some instances. Conditions involving obvious major damage are omitted, as are those caused by accident or an unusual chain of events which would require evaluation by a competent authority. Notes below provide information in addition to that available in trouble shooting chart and in maintenance instructions for systems and components of power train.

INDICATION OF TROUBLE	PROBABLE CAUSE	CORRECTIVE ACTION
TRANSMISSION:		
Low oil pressure		
(1) On caution panel or pressure gage, but not both	Faulty caution panel or gage circuit or unit	Repair electrical circuit or replace faulty unit
(2) Shown by both caution panel and gage	Pressure relief valve malfunction	Adjust or replace valve
	Clogged pump screen	Clean screen, check oil for chips or contamination
	Faulty oil pump	Replace pump
	Leakage or restriction between pressure relief valve and transmitter	Repair oil line connections or replace seals
No oil pressure		
(1) With normal oil level	Faulty gage or transmitter or circuit	Repair circuit or replace faulty unit
	Oil pump failure	Replace transmission or if transmission is not internally damaged, replace pump only
(2) No oil supply	Leak in system or failure to service	Replace transmission. Also replace cooler, flush and repair external lines
Grease leakage at tail rotor drive coupling	Damaged seal	Replace seal in quill

INDICATION OF TROUBLE	PROBABLE CAUSE	CORRECTIVE ACTION
High oil pressure	Faulty gage or transmitter or circuit	Repair circuit or replace faulty unit
	Pressure relief valve malfunction	Adjust or replace
High oil temperature	Pressure relief valve malfunction	Adjust or replace valve
(1) On caution panel or temperature gage, but not both	Faulty caution panel or gage circuit or unit	Repair circuit or replace faulty unit
(2) Shown on both caution panel and gage	Obstructed air flow around transmission	Clear cowl opening and sump area

These questions were answered by the Vietnamese airmen after reading one of three translations of the preceding section of the UH-1H TM.

Please read the Vietnamese passage about the helicopter. After you read the passage, answer the ten questions. Write down the exact words in the Vietnamese essay that allows you to answer each of the ten questions.

1. The passage provides instructions for the maintenance of helicopters. Who is authorized to perform the maintenance?

2. Name the parts that the main transmission includes?

3. There are two methods that allow conditions and possible causes to become known. Name one of the methods.

4. There are two kinds of conditions that are omitted. Name one of the conditions.

5. There are two ways that low oil pressure is indicated. Name one of the two ways.

6. Is a faulty oil pump an

   (a) indication of trouble
   (b) a probable cause, or
   (c) a corrective action?

7. If there is a grease leakage at tail rotor drive coupling, what is the corrective action?

8. If the corrective action is to replace the transmission and also replace cooler, flush and repair external lines, what is the probable cause that led to that action?

9. When high oil pressure is an indication of trouble, there are two probable causes. Name one of the two probable causes.

10. If the probable cause of a trouble is an obstructed air flow around transmission, what is the corrective action?

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13. ABSTRACT

This paper documents the results of a series of experiments conducted by the Institute for Defense Analyses on translating technical material from English to Vietnamese. The work was accomplished in support of the ODDR&E, Deputy Director for Southeast Asia Matters.

The paper addresses the questions of translation speed, number of errors, and quality assessment. Three different methods for measuring the quality of translations are examined; back-translation, knowledge testing, and performance testing. Translation costs and means of writing translatable English are also reviewed.

It is concluded that: 400 words per hour is a reasonable speed expectation for technical material; quality of translation significantly affects performance and quality may be sampled by any of the means tested; costs can be reduced by several methods but $70 per thousand words is a reasonable estimate.

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT